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(54) **Cryogenic container with built-in refrigerator**

Kryogenbehälter mit eingebautem Kühlaggregat

Conteneur cryogène avec réfrigérateur intégré

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(56) References cited:  
**EP-A1- 1 610 074** **CN-A- 1 818 508**  
**US-A1- 2007 261 416**

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**EP 2 085 720 B1**

## Description

### TECHNICAL FIELD:

**[0001]** The present invention relates to a cryogenic container with a built-in refrigerator of the kind referred to in the preamble portion of patent claim 1. Such a cryogenic container is known from EP 1 610 074 A1.

### BACKGROUND ART:

**[0002]** JP 11-87131 A discloses a refrigerator system, wherein a cryogenic part of a refrigerator and a object to be cooled are disposed in a vacuum vessel to prevent heat leak from a room temperature area in order to keep the object at a lower temperature when the object to be cooled such as a superconducting magnet is cooled to a cryogenic temperature.

**[0003]** When a very small superconducting magnet is to be cooled, the refrigerator should be very small.

**[0004]** FIG. 4 shows an example of refrigerator cooling performance. The figure shows refrigerator cooling performance in relation to refrigerator cooling temperature where a parameter is an ambient temperature for the refrigerator, or a temperature of helium gas as a cooling medium at an inlet of the refrigerator in cooling operation in the environment in which the refrigerator is installed. For example, if heat leak into a cryogenic part of a vacuum vessel is 0.3 W, regarding the cooling temperature of the refrigerator in the refrigerator system, the superconducting magnet cooling temperature is 48 K at the ambient temperature  $T_r$  of 296 K but it is 55 K at the ambient temperature of 318 K in summer.

**[0005]** If the superconducting magnet is prepared by magnetizing a cylindrical yttrium oxide bulk superconductor in a high magnetic field, an intensity of the magnetized field sharply decreases when the bulk superconductor cooling temperature exceeds 50 K. For example, if a diameter of the cylindrical bulk superconductor is 45 mm, the intensity of the magnetized field is 6 Tesla at the bulk superconductor cooling temperature of 48 K but it is 4 Tesla at the bulk superconductor cooling temperature of 55 K, leading to a serious decline in the magnetic field performance of the superconducting magnet. Once the magnetic field performance declines, even if the cooling temperature goes down to 48 K again, the magnetic field intensity will remain 4 Tesla, namely the magnetic field performance will remain low.

**[0006]** On the contrary, when the ambient temperature goes down to 273 K in winter, the superconducting magnet cooling temperature is 45 K and the intensity of the magnetized field goes up to 6.5 Tesla.

**[0007]** As described above, if adiabatic expansion of helium gas as a cooling medium is used for cooling, the lower the temperature of the helium gas as cooling medium at the inlet of the refrigerator is, the lower the temperature of the cryogenic part of the refrigerator is. In a process of compressing the helium gas supplied to the

refrigerator by a compressor, the gas is heated to approximately 353 K by compression heat and if this heat is directly or indirectly discharged to the room, the ambient temperature as shown in FIG. 4 may actually become 10-20 K higher than the room temperature.

**[0008]** Therefore, there is a problem that the inlet temperature of the helium gas as the cooling medium for the refrigerator may be higher than the room temperature and the cooling temperature of the refrigerator may be higher than when the inlet temperature of the refrigerator is lower than the room temperature.

**[0009]** Indecreasing the cooling temperature of the refrigerator by further decreasing the helium gas inlet temperature, the helium gas heated by the compression heat is cooled by cooling water whose temperature is lower than the room temperature, so that the helium gas inlet temperature is made lower than the room temperature before the gas is supplied to the refrigerator.

**[0010]** As disclosed in JP 11-87131 A, since an inlet portion of a refrigerator is located outside a vacuum vessel and exposed to a room temperature area, if helium gas inlet temperature is lower than the dew point in the room, condensation of moisture in the air occurs at the inlet portion, resulting in water drops outside of the refrigerator. Also, as a result of the condensation of moisture in the air at the inlet portion, a problem may arise that the temperature of the helium gas at the inlet of the refrigerator rises and the cooling temperature of the refrigerator rises.

**[0011]** JP 2004-144399 A discloses a means for controlling a temperature using an electronic device such as a Peltier element without using cooling water. This means comprises a refrigerating cycle using carbon dioxide as a refrigerant, where a motive energy recovered by an expansion device is used for refrigerant heat exchange between a dissipating heat exchanger in an atmospheric air and an outlet of the expansion device using the Peltier element.

**[0012]** JP 2002-181437 A discloses a means for dissipating exhaust heat from a compressor of a refrigerator system through a heat pipe. In this means, a cryogenic part and a hot part of the refrigerator are disposed in a hermetically sealed case in order to prevent penetration of raindrops and a heat dissipating part for the heat pipe is provided outside the case, and the hot part and the heat dissipating part are connected by the heat pipe. The heat in the hot part is discharged through the cooling medium in the heat pipe to an atmosphere of a room temperature and the temperature of the hot part is always kept higher than the room temperature. In this means as well, no dew condensation occurs since the refrigerant used for the temperature control is higher than the room temperature.

**[0013]** However, since the temperature of the cooling medium at the inlet of the refrigerator is higher than the room temperature, there is a problem that the cooling temperature of the refrigerator is higher than when the temperature of the cooling medium at the inlet of the re-

frigerator is lower than the room temperature. In addition, since the case is hermetically sealed, the air temperature inside the case is always higher than the room temperature and there is more heat leak into the cryogenic part of the refrigerator than the air temperature inside the case is equal to the room temperature, leading to a temperature rise in a cooling part of the refrigerator.

**[0014]** In the means disclosed in JP 2002-181437 A, when the refrigerator is hermetically sealed by the case, the cryogenic part of the refrigerator must be insulated sufficiently and thus the case must be large and the volume and weight of the entire refrigerator system must be larger.

**[0015]** Instead of using the hermetically sealed case, it is also possible to cover the refrigerator with a foaming agent or the like and fill gaps with an adhesive agent. However, since foaming agents are usually flammable, possibility of burning of such covered portions cannot be eliminated and safety is not ensured in a place where a high degree of fire protection is required.

**[0016]** The problem inherent to the above related art is as follows. When the inlet temperature of the helium gas as the cooling medium for the refrigerator is decreased to a level lower than a dew point in the room in order to make the cooling temperature of the refrigerator system lower and an inlet portion of the cooling medium is exposed to the air, moisture in the air may result in dew condensation and the condensation may cause the temperature of the cooled helium gas to go up again.

**[0017]** EP 1 610 074 A1 discloses a cryogenic container with a built-in refrigerator comprising the refrigerator having a first heat absorbing part and a first heat dissipating part; a vacuum vessel for containing and thermally insulating an object to be cooled while holding the object at a cryogenic temperature through the first heat absorbing part of the refrigerator; and a pre-cooling unit having a second heat absorbing part and a second heat dissipating part for cooling the first heat dissipating part; wherein the first heat dissipating part and the second heat absorbing part are arranged inside the vacuum vessel, and a part of a heat dissipating unit including the second heat dissipating part is exposed outside the vacuum vessel, wherein the refrigerator uses a gas as a cooling medium and has a compressing part for mechanically compressing the cooling medium.

**[0018]** An object of the present invention is to provide a cryogenic container with a built-in refrigerator capable of cooling an object to a cryogenic temperature, wherein a temperature of a heat dissipating surface of a compressing part of the refrigerator is decreased to a level lower than the room temperature to improve an efficiency of the refrigerator, and also a temperature of a cooling medium at an inlet of the refrigerator is controlled to a level lower than the room temperature without causing a dew condensation on an outer surface of the cryogenic container and heat leak into the refrigerator from the room temperature area is reduced to keep the cooling temperature of the refrigerator low enough.

**[0019]** According to the present invention, this object is accomplished with a cryogenic container with a built-in refrigerator as claimed in claim 1.

**[0020]** Dependent claims are directed on features of preferred embodiments of the invention.

**[0021]** According to the present invention, in the cryogenic container with the built-in refrigerator capable of cooling the object to be cooled to the cryogenic temperature, the refrigerator efficiency can be improved by cooling a heat dissipating surface of the first heat dissipating part of the refrigerator to a level lower than the room temperature. Furthermore, since the compressing part of the refrigerator to be pre-cooled by the pre-cooling unit to the temperature lower than the room temperature is contained inside the vacuum space, there is no possibility that condensation of moisture in the air occurs and thus electric short-circuiting due to dew condensation and failures due to dew condensation in transportation can be prevented.

#### BRIEF DESCRIPTION OF THE DRAWINGS:

##### **[0022]**

FIG. 1 is a schematic sectional view illustrating a structure of a cryogenic container with a built-in refrigerator according to a first embodiment of the present invention.

FIG. 2 is a schematic sectional view illustrating the structure of a cryogenic container with a built-in refrigerator according to a second embodiment of the present invention.

FIG. 3 is a schematic sectional view illustrating the structure of a cryogenic container with a built-in refrigerator according to a third embodiment of the present invention.

FIG. 4 is a graph illustrating a cooling characteristics of the refrigerator used in the embodiments of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS:

**[0023]** A cryogenic container with a built-in refrigerator is characterized in that it uses gas as a cooling medium and comprises a compressing part and a vacuum vessel. The compressing part has a function of compressing the cooling medium mechanically and comprises a first heat dissipating part. A vacuum vessel contains the refrigerator including a first heat absorbing part for generating cryogenic energy by adiabatic expansion of the cooling medium, and an object to be cooled and kept at a cryogenic temperature by the refrigerator, and insulates the refrigerator and the object. Further, A vacuum vessel contains a pre-cooling unit for cooling the first heat dissipating part. And the cryogenic container with a built-in refrigerator can discharge exhaust heat from the pre-cooling unit to the air.

**[0024]** The cryogenic container with the built-in refrigerator according to the present invention is also characterized in that the helium gas at the inlet of the refrigerator is cooled to a temperature lower than the room temperature in order to decrease its cooling temperature. Further, an isolating means for isolating the refrigerator inlet portion for helium gas from the air is arranged in the cryogenic container and a space inside the isolating means is an insulating space and the thermally conductive medium in the insulating space is removed.

**[0025]** The cryogenic container with the built-in refrigerator according to the present invention is also characterized in that the pre-cooling unit for cooling the helium gas as the refrigerator cooling medium at the refrigerator inlet to a level lower than the room temperature is located inside the insulating space, and a hot part of the pre-cooling unit with a temperature higher than the room temperature and a partition for constituting the isolating means and being contact with the air are thermally connected by a thermally conductive member with a high thermal conductivity. A leak of a heat into a cooling part of the pre-cooling unit is prevented by dissipating the heat of the hot part of the pre-cooling unit through the partition (room temperature) to the air, and a rise of the temperature of the helium gas at the refrigerator inlet is controlled.

**[0026]** The cryogenic container with the built-in refrigerator according to the present invention is characterized in that a high insulating performance with a small space is assured by evacuating the insulating space, and discharging air and keeping a vacuum condition prevent combustion or ignition even if the temperature inside the space is higher. And a compact and fireproof cryogenic container is obtained thereby.

**[0027]** Next, the preferred embodiments of the present invention will be described in detail.

[First Embodiment]

**[0028]** FIG. 1 is a sectional view illustrating a small superconducting magnet system wherein an object to be cooled is a cylindrical yttrium-based bulk superconductor including Y (yttrium), Ba (barium), Cu (copper) and O (oxygen).

**[0029]** A cryogenic container with a built-in refrigerator according to a first embodiment is a small and light container for cooling a bulk superconductor 1 as the object to be cooled. This cryogenic container with the built-in refrigerator contains a Stirling refrigerator as a cooling means for cooling the object, the Stirling refrigerator generating cryogenic energy by compressing helium gas as a cooling medium and adiabatically expanding the compressed helium gas. The refrigerator comprises a cooling part 2, a compressing part 3, a pre-cooling stage 4 included in the compressing part 3 for dissipating a compression heat of the compressing part 3 to an outside of the refrigerator, a thermally conductive plate 5 located in contact with the pre-cooling stage 4, a Peltier element 6

as a pre-cooling unit located in contact with the thermally conductive plate 5, a thermally conductive plate 7 located in contact with a hot heat dissipating surface of the Peltier element 6, a vacuum vessel 10, a thermally conductive plate 9 located in contact with an inner wall of the vacuum vessel 10, and a copper net 8 located in contact with the thermally conductive plate 7 and thermally conductive plate 9. The pre-cooling stage 4 cools the compressing part 3 of the refrigerator in combination with the thermally conductive plate 5 by transferring the heat generated in the compressing part 3 to the cooling surface of the Peltier element 6. The hot helium gas without expanding inside the compressing part 3 is thus cooled.

**[0030]** Here, the cooling part 2 of the refrigerator is defined as a first heat absorbing part. The pre-cooling stage 4 included in the compressing part 3 of the refrigerator is defined as a first heat dissipating part. The cooling surface of the Peltier element 6 for cooling the pre-cooling stage 4 is defined as a second heat absorbing part. And a hot heat dissipating surface of the Peltier element 6 is defined as a second heat dissipating part.

**[0031]** The copper net 8 is a thermally conductive member for transferring the exhaust heat of the Peltier element 6 from the thermally conductive plate 7 to the thermally conductive plate 9. This thermally conductive member is not limited to the copper net 8 but may be any flexible member with a high thermal conductivity such as a bundle of copper wires, an aluminum net or a bundle of aluminum wires. It should be flexible enough to absorb vibrations of the refrigerator and reduce vibrations transmitted to an outside of the vacuum vessel 10 and prevent collapse due to vibrations of the refrigerator.

**[0032]** In this embodiment, the thermally conductive plate 9 is tightly fixed on the inner wall of the vacuum vessel 10 with a bolt 11. It is desirable that a heat dissipating surface of the vacuum vessel 10 be made of a metal with a high thermal conductivity such as copper.

**[0033]** The second heat dissipating part (hot heat dissipating surface of the Peltier element 6), thermally conductive plate 7, the copper net 8 (the thermally conductive member), thermally conductive plate 9, and the heat dissipating surface of the vacuum vessel 10 are collectively defined as a heat dissipating unit. This heat dissipating unit may lack one or some or all of following components: the thermally conductive plate 7, the copper net 8 (the thermally conductive member), the thermally conductive plate 9, and the heat dissipating surface of the vacuum vessel 10 except the second heat dissipating part (the hot heat dissipating surface of the Peltier element 6). In other words, the heat dissipating unit may only consist of the second heat dissipating part.

**[0034]** The hot heat dissipating surface of the Peltier element 6, the thermal conductors 5 and 7 are fastened through an indium sheet or the like with a bolt or connected by soldering (not shown).

**[0035]** The bulk superconductor 1 is fixed on an inside of a holder 12 of copper or stainless steel with an adhesive agent or the like. The holder 12 is formed of a material

functioning both as a reinforcing member and a thermally conductive member. The holder 12 is coupled with a support 13 made of a material with a high thermal conductivity such as aluminum or copper using screws or the like. The support 13 is fixed on a top of a supportive cylinder 14 of a glass fiber-filled epoxy resin with a low thermal conductivity by an adhesive agent or the like. And the supportive cylinder 14 is fixed on a flange 15 at its bottom by an adhesive agent and fastened to an inner wall of the vacuum vessel 10 with a bolt or the like (not shown).

**[0036]** A thermal conductor 16 formed of a flexible copper net or a ring made of a copper thin belt with a high thermal conductivity is arranged between the support 13 and the cooling part 2 of the Sterling refrigerator and they are connected with each other by soldering or another method. Soldering operation here can be done using a hole 17 in the supportive cylinder 14 and a soldering iron.

**[0037]** Electric power is supplied from a power supply unit 18 to the compressing part 3 of the refrigerator and Peltier element 6 through wires 19a and 19b.

**[0038]** An upper part 20 of the vacuum vessel 10 is made of, for example, a glass fiber-filled epoxy resin. A flange 21 is joined to a lower part 110 of the vacuum vessel 10 by welding or blazing, and a flange 22 is joined to an upper part 20 of the vacuum vessel 10 with an adhesive agent. These flanges 21 and 22 are coupled through an O ring (not shown) with a bolt 23 and a nut 24. This ensures an air tightness of the vacuum vessel 10.

**[0039]** The compressing part 3 of the refrigerator is fixed on a retaining plate 25 joined to an inner wall of the vacuum vessel 10 through a vibration isolating cushion 33 with a bolt (not shown). A space 26 inside the vacuum vessel 10 is evacuated by a vacuum pump 30 through a nozzle 27, a valve 28 and a tube 29. The vibration isolating cushion 33 is not limited to a rubber but may be any flexible member for suppressing transmission of vibrations. Such a member is defined as a vibration isolating member. Activated carbon particles 32, for example, are contained inside the vacuum vessel 10 for the purpose of absorbing a residual gas (air, etc) in the space 26 and keeping the required degree of vacuum.

**[0040]** A distance between an upper end of the cooling part 2 of the refrigerator and a bottom of the support 13 changes from before an operation of the refrigerator to during the operation because of thermal deformation. However, the flexible thermal conductor 16 reduces a large thermal stress on the cooling part 2 and the support 13.

**[0041]** The compressing part 3 of the refrigerator is joined to the retaining plate 25 joined to an inner wall of the vacuum vessel 10 with a bolt (not shown) through the rubber cushion 33. Since the compressing part 3 of the Sterling refrigerator considerably vibrates during operation and the vibration is directly transmitted to the vacuum vessel 10 and the vacuum vessel 10 itself vibrates, resonates and generates a noise, the rubber cushion 33 is used to reduce the vibration. A fin 31 is disposed on

the vacuum vessel 10 to improve a heat dissipating performance.

**[0042]** In this embodiment, if a heat leaking into a cryogenic zone inside the vacuum vessel 10 is 0.3 W, a compression heat 7 W generated in the compressing part 3 of the refrigerator must be dissipated to the outside of the refrigerator. If the Peltier element 6 generates a temperature difference of 50 K at a cooling power of 7 W, the thermally conductive plate 5 cooled by the Peltier element 6 is cooled to 273 K. The heat dissipated by the Peltier element 6 here is estimated to be 20 W. A temperature of the thermally conductive plate 7 being in contact with the hot heat dissipating surface of the Peltier element 6 becomes 323 K, and the heat is dissipated through the copper net 8 to heat dissipating surface of the vacuum vessel 10 whose temperature is 10 K lower, or 313 K (room temperature).

**[0043]** In the above case, the temperature of pre-cooling stage 4 of the refrigerator disposed inside the vacuum vessel 10 is 273 K and the bulk superconductor 1 is cooled to approximately 45 K. If a diameter of the cylindrical bulk superconductor 1 is 45 mm, a magnetized field intensity is higher than 6 Tesla, or 6.5 Tesla, at a bulk superconductor cooling temperature of 48 K.

**[0044]** In a related art, in order to remove the compression heat (7 W) generated in the compressing part 3 without using the Peltier element 6 at a room temperature of 313K, the compressing part 3 is exposed outside the vacuum vessel 10 to dissipate the heat. In this case, however, a heat dissipating surface area is small and a temperature of the compressing part 3 is approximately 318 K. Since this temperature is the ambient temperature for the refrigerator, the cooling temperature of the bulk superconductor 1 is 55 K and the magnetized field intensity is 4 Tesla.

**[0045]** In this embodiment, the compressing part 3 of the refrigerator is pre-cooled by the Peltier element 6 to make its temperature lower than the room temperature and the bulk superconductor 1 being cooled by the refrigerator is cooled to 50 K or less. Therefore, the magnetized field intensity of the bulk superconductor 1 is increased.

**[0046]** Furthermore, in this embodiment, since the Peltier element 6 for cooling the compressing part 3 of the refrigerator is disposed inside the vacuum vessel 10, there is no possibility that a condensation of moisture in the air occurs on the cooling surface of the Peltier element 6 and thus electric short-circuiting due to the dew condensation and failures due to the condensed moisture in transportation can be prevented.

**[0047]** Furthermore, since the Peltier element 6 is disposed inside the vacuum vessel 10, the cryogenic part of the Peltier element 6 is thermally insulated from the room temperature area. Therefore, the cooling efficiency of the Peltier element 6 is improved and the compressing part 3 of the refrigerator is cooled to a lower temperature and the bulk superconductor 1 can be cooled to 50 K or less by the refrigerator.

**[0048]** In addition, since the Peltier element 6 is disposed inside the vacuum vessel 10, there is no air layer around the hot part of the Peltier element 6. This prevents a transfer of the heat from the hot part of the Peltier element 6 to the compressing part 3 (located near to the hot part) through an air layer. For this reason, the compressing part 3 of the refrigerator can be cooled to a lower temperature and the bulk superconductor 1 can be cooled to 50 K or less by the refrigerator. Since the magnetization performance is enhanced, it is possible to provide a superconducting magnet generating a higher-intensity magnetic field.

#### [Second Embodiment]

**[0049]** FIG. 2 shows another embodiment of the present invention. The difference from FIG. 1 is that the refrigerator is a split-type Sterling refrigerator wherein its cooling part 34 and compressing part 35 are separate from each other and connected by a tube 36. In this embodiment, the cooling part 34 of the refrigerator and the compressing part 35 of the refrigerator are fixed through a supportive plate 37 and through a rubber cushion 33 respectively on a retaining plate 38 fixed on the inner wall of the vacuum vessel 10 with bolts or the like (not shown). In this embodiment, the cooling part 34 and the hot compressing part 35 are separated from each other through the tube 36 with a small sectional area so that a heat leak from the compressing part 35 into the cooling part 34 by thermal conduction can be reduced. Consequently, the cooling part 34 can be cooled to a lower temperature and the magnetization performance can be enhanced by decreasing the temperature of the bulk superconductor 1 to realize a superconducting magnet with a higher magnetic field intensity. In addition, a transmission of vibrations of the compressing part 35 to the bulk superconductor 1 as the object to be cooled is reduced.

**[0050]** Even when the refrigerator is of the split type, since the Peltier element 6, the temperature of which becomes lower than the room temperature, is disposed inside the vacuum vessel 10, there is no possibility that the condensation of moisture in the air occurs on the cooling surface of the Peltier element 6 and thus electric short-circuiting due to the dew condensation and the failures due to the condensed moisture in the transportation can be prevented.

#### [Third Embodiment]

**[0051]** FIG. 3 shows another embodiment of the present invention. The difference from FIG. 1 is that a fan 39 is arranged on the bottom of the vacuum vessel 10. An electric power is supplied to the fan 39 from the power supply 18 by wire 19C and the fan 39 send air to the fin 31. This improves the heat dissipating performance of the fin 31.

**[0052]** In this embodiment, since an operation of the fan 39 improves the heat dissipating performance of the

fin 31, the temperature of the thermally conductive plate 7 becomes further lower and thus the temperature of the thermally conductive plate 5 also becomes lower. Consequently the temperature of the cooling part 34 of the refrigerator becomes further lower and the temperature of the bulk superconductor 1 becomes lower so that the magnetization performance is enhanced and a superconducting magnet generating a higher-intensity magnetic field is realized.

**[0053]** The above embodiments assume that the refrigerator for cooling the object to be cooled is a Sterling refrigerator. However, even if the refrigerator is another type of refrigerator such as a Gifford-McMahon refrigerator, a pulse tube refrigerator or a thermoacoustic refrigerator, a similar advantageous effect can be achieved.

**[0054]** Besides, although the above embodiments assume that the object to be cooled is a bulk superconductor, the invention can be applied even when the object to be cooled is a cell sample or a protein sample. If that is the case, it is desirable that one end of the cryogenic container be open to the air to allow a user to take in and out the sample to be kept cold. In this case as well, since the pre-cooling unit decreases the helium gas inlet temperature to a level lower than the room temperature and thereby further decreases the temperature of the cryogenic container, the same advantageous effect that no dew condensation occurs on the cooling surface of the pre-cooling unit is achieved.

**[0055]** In the above embodiments, the entire Peltier element 6 as the pre-cooling unit is disposed inside the vacuum vessel 10. However, it is also possible that the cooling surface of the Peltier element 6 as the second heat absorbing part is disposed inside the vacuum vessel 10 and the hot heat dissipating surface of the Peltier element 6 as the second heat dissipating part is exposed outside the vacuum vessel 10. In this case as well, the temperature of the pre-cooling stage 4 as the first heat dissipating part can be below the dew point in the room and the dew condensation can be reduced.

**[0056]** According to the present invention, in a cryogenic container with a built-in refrigerator capable of cooling the object to be cooled to a cryogenic temperature, the efficiency of the refrigerator is improved by cooling the heat dissipating surface of its first heat dissipating part to a level lower than the room temperature.

**[0057]** Furthermore, according to the present invention, since compressing part of the refrigerator to be pre-cooled by the pre-cooling unit to below the room temperature is disposed in the vacuum space, there is no possibility that the condensation of moisture in the air occurs and thus the electric short-circuiting due to the dew condensation and the failures due to the dew condensation in transportation can be prevented. Moreover, according to the present invention, the helium gas temperature at the inlet of the refrigerator is kept lower than the room temperature so that the object to be cooled by the refrigerator can be cooled to a lower temperature.

**[0058]** Also, according to the present invention, since

the insulating vacuum vessel contains no oxygen, it is excellent in fire protection and assures safety in a place where a high degree of fire protection is required.

## Claims

1. A cryogenic container with a built-in refrigerator comprising:

the refrigerator having a first heat absorbing part (2) and a first heat dissipating part (4);  
a vacuum vessel (10) for containing and thermally insulating an object (1) to be cooled while holding the object (1) at a cryogenic temperature through the first heat absorbing part (2) of the refrigerator; and  
a pre-cooling unit (4) having cooling surface which is defined as a second heat absorbing part and having a heating surface which is defined as a second heat dissipating part for cooling the first heat dissipating part (4);  
wherein the first heat dissipating part (4) and the second heat absorbing part are arranged inside the vacuum vessel (10), and a part of a heat dissipating unit including the second heat dissipating part is exposed outside the vacuum vessel (10), wherein the refrigerator uses a gas as a cooling medium and has a compressing part (3) for mechanically compressing the cooling medium; **characterized in that** the compressing part (3) includes the first heat dissipating part (4).

2. The cryogenic container with the built-in refrigerator according to Claim 1, wherein the heat dissipating unit (6, 7, 8, 9, 10) includes a thermally conductive member.
3. The cryogenic container with the built-in refrigerator according to Claim 1, wherein the pre-cooling unit (4) comprises a Peltier element (6).
4. The cryogenic container with the built-in refrigerator according to Claim 1, wherein a vibration isolating member (33) is arranged between the compressing part (3) and an inner wall of the vacuum vessel (10).
5. The cryogenic container with the built-in refrigerator according to Claim 1, wherein the first heat absorbing part (34) and the compressing part (35) are connected by a tube (36).

## Patentansprüche

1. Kryogenbehälter mit eingebautem Kühlaggregat, mit:

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einem Kühlaggregat mit einem ersten wärmeabsorbierenden Teil (2) und einem ersten wärmeabgebenden Teil (4),  
einem Vakuumkessel (10) zum Aufnehmen und thermischen Isolieren eines Objekts (1), welches zu kühlen ist, während das Objekt (1) durch den ersten wärmeabsorbierenden Teil (2) des Kühlaggregats auf einer tiefkalten Temperatur gehalten wird, und  
einer Vorkühlungseinheit (4) mit einer Kühlfläche, die definiert ist als ein zweiter wärmeabsorbierender Teil, und mit einer Heizfläche, die definiert ist als ein zweiter wärmeabgebender Teil zum Kühlen des ersten wärmeabgebenden Teils (4),  
wobei der erste wärmeabgebende Teil (4) und der zweite wärmeabsorbierende Teil innerhalb des Vakuumkessels (10) angeordnet sind, und ein Teil der wärmeabgebenden Einheit, der den zweiten wärmeabgebenden Teil umfasst, außerhalb des Vakuumkessels (10) angeordnet ist, wobei das Kühlaggregat ein Gas als Kühlmedium verwendet und einen Kompressorteil (3) aufweist zum mechanischen Komprimieren des Kühlmediums,

**dadurch gekennzeichnet, dass** der komprimierende Teil (3) den ersten wärmeabgebenden Teil (4) umfasst.

2. Kryogenbehälter mit eingebautem Kühlaggregat nach Anspruch 1, wobei die wärmeabgebende Einheit (6, 7, 8, 9, 10) ein thermisch leitendes Element umfasst.
3. Kryogenbehälter mit eingebautem Kühlaggregat nach Anspruch 1, wobei die Vorkühlungseinheit (4) ein Peltierelement (6) umfasst.
4. Kryogenbehälter mit eingebautem Kühlaggregat nach Anspruch 1, wobei ein vibrationsisolierendes Element (33) zwischen dem komprimierenden Teil (3) und einer Innenwand des Vakuumkessels (10) angeordnet ist.
5. Kryogenbehälter mit eingebautem Kühlaggregat nach Anspruch 1, wobei der erste wärmeabsorbierende Teil (34) und der komprimierende Teil (35) durch ein Rohr (36) miteinander verbunden sind.

## Revendications

1. Conteneur cryogénique avec un réfrigérateur intégré comprenant :

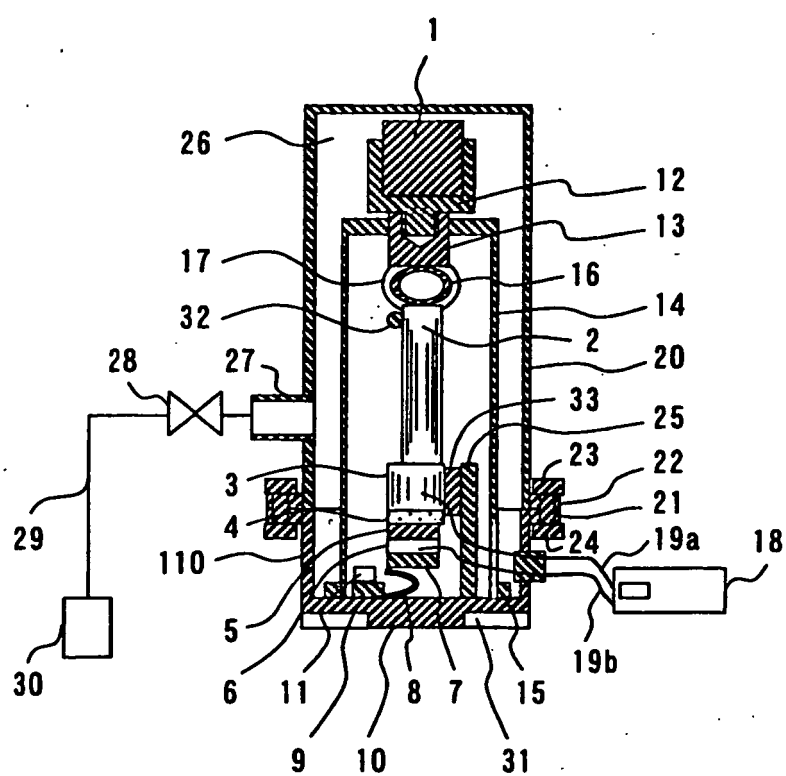
le réfrigérateur ayant une première partie d'absorption de chaleur (2) et une première partie

de dissipation de chaleur (4) ;  
 une chambre à vide (10) pour contenir et isoler thermiquement un objet (1) devant être refroidi tout en maintenant l'objet (1) à une température cryogénique par l'intermédiaire de la première partie d'absorption de chaleur (2) du réfrigérateur ; et  
 une unité de pré-refroidissement (4) ayant une surface de refroidissement qui est définie comme une deuxième partie d'absorption de chaleur et ayant une surface de chauffage qui est définie comme une deuxième partie de dissipation de chaleur pour refroidir la première partie de dissipation de chaleur (4) ;  
 dans lequel la première partie de dissipation de chaleur (4) et la deuxième partie d'absorption de chaleur sont agencées à l'intérieur de la chambre à vide (10), et une partie d'une unité de dissipation de chaleur incluant la deuxième partie de dissipation de chaleur est exposée à l'extérieur de la chambre à vide (10), dans lequel le réfrigérateur utilise un gaz comme un agent de refroidissement et a une partie de compression (3) pour compresser mécaniquement l'agent de refroidissement ;

**caractérisé en ce que** la partie de compression (3) inclut la première partie de dissipation de chaleur (4).

2. Conteneur cryogénique avec le réfrigérateur intégré selon la revendication 1, dans lequel l'unité de dissipation de chaleur (6, 7, 8, 9, 10) inclut un élément thermoconducteur.
3. Conteneur cryogénique avec le réfrigérateur intégré selon la revendication 1, dans lequel l'unité de pré-refroidissement (4) comprend un élément de Peltier (6).
4. Conteneur cryogénique avec le réfrigérateur intégré selon la revendication 1, dans lequel un élément d'isolation de vibrations (33) est agencé entre la partie de compression (3) et une paroi intérieure de la chambre à vide (10).
5. Conteneur cryogénique avec le réfrigérateur intégré selon la revendication 1, dans lequel la première partie d'absorption de chaleur (34) et la partie de compression (35) sont connectées par un tube (36).

**FIG. 1**



**FIG. 2**

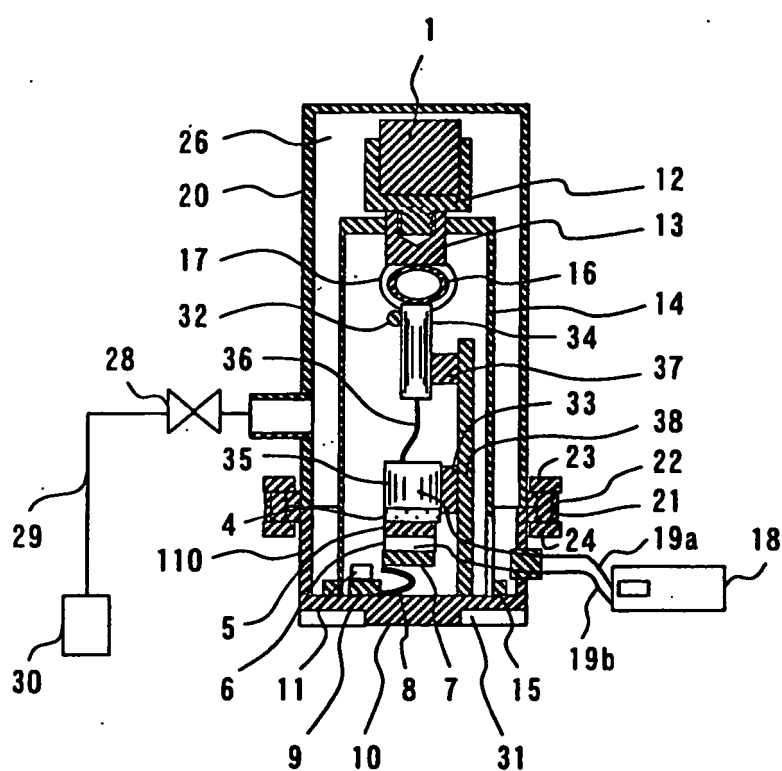


FIG. 3

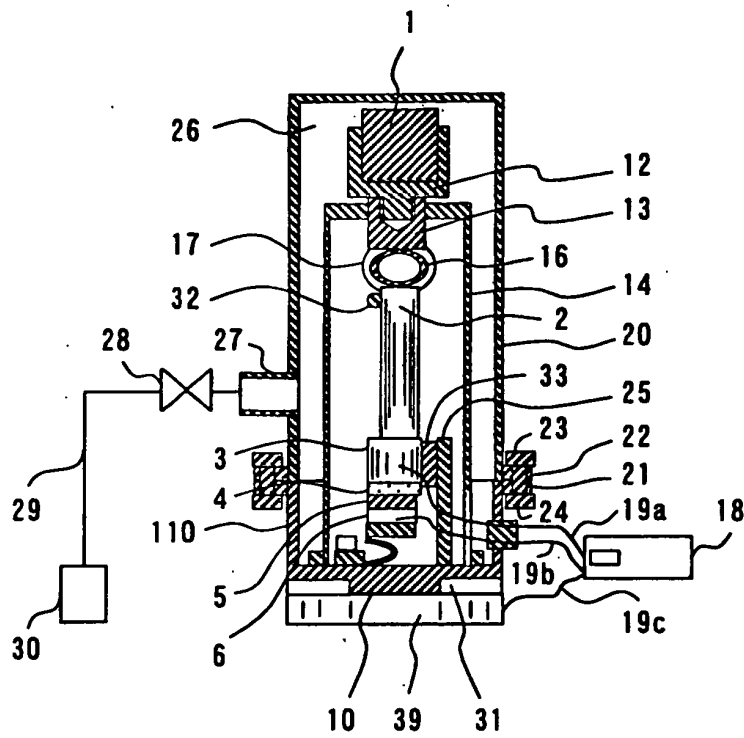
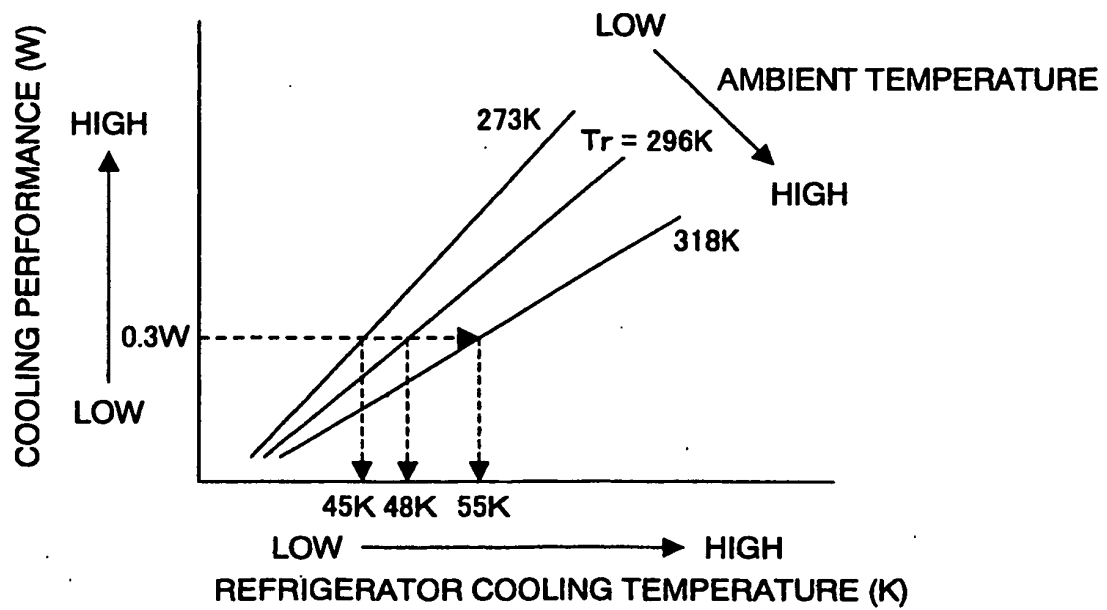


FIG. 4



**REFERENCES CITED IN THE DESCRIPTION**

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